

Additions to the marine alien fauna of Greek waters (2007 update)

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The list of marine alien fauna in Greek waters is updated taking into account new findings (published and unpublished data). According to the present work, the number of species increases from 102 to 110. Of the eight new records, five are zoobenthic species, two zooplanktonic and another one a teleost fish. Moreover, records referring to the expansion range of aliens from an established stand to new areas are also presented, pointing out the species that could be considered as possible invaders to local communities.

INTRODUCTION

Alien species are rapidly changing our marine and freshwater ecosystems. The number of biological invasions has grown dramatically in recent decades, causing serious ecological and economic impacts. The Mediterranean Sea is subject to the ever-increasing arrival of non-indigenous marine organisms, and is undergoing a dramatic change in its species composition (Zibrowius, 2002). In the Greek Seas a multi-annual trend analysis based on a recently prepared inventory of alien species revealed their important increase during the last years (Pancucci-Papadopoulou *et al.*, 2005). The increased rate of introductions in the Greek Seas could be the result of a synergy of different causes, the most important of which are the following: (a) the intensive research on the marine biota of the Greek Seas during the last two decades and the relatively improved public awareness, which has led to the discovery of many species not reported previously; (b) the increased anthropogenic activities in the Greek Seas over the last decade such as aquaculture and tourism (contributing factors to increase of maritime traffic) favouring the unintentional introduction of aliens. Moreover increased disturbance from other human activities is known to make marine ecosystems more vulnerable to aliens; and (c) global warming creating suitable conditions for the introduction and/or range expansion of non-native species and particularly certain thermophile lessepsian immigrants.

The present work is based on updated faunal records that have been gathered from research papers, biota surveys and conference abstracts. The list is doubtlessly an underestimate since according to Carlton (2000) the number of recorded invasions is restricted to very large or very abundant species and to invaders that are of clear, obvious, and immediate economic or human health-related concerns.

MATERIALS AND METHODS

The species listed below fall into two categories: (a) the new records for Greece; and (b) the previously recorded species that have spread, among which some seem to be well established.

Recent research by SCUBA diving and free diving in several coastal localities of the south Aegean Sea has revealed that many little known species (referred as casual in Pancucci-Papadopoulou *et al.*, 2005) are now well established along the Greek Seas. Some of the target species were photographed and released, with a few of them deposited in the Hellenic Centre for Marine Research (HCMR) collection. In addition to systematic studies of zoobenthos in hard substrata, some fish records are derived from commercial and sport fishery. Sources of information for the present compilation include mostly grey literature such as HCMR and EU technical reports, 2005–2006 Scientific Congresses, personal communication by specialists, website (sea slug forum), 2006–2007 publications, as well as data existing in the Integrated Database and GIS System (IMAS-Fish, 2007) of the HCMR. Data in these databases are inherently verified and supported by the scientific authority of the supervising researchers in charge of the institute.

RESULTS

A. New records for Greek Seas

In Table 1 the total number of fish, zoobenthos and zooplankton alien species recorded in Greek waters till July 2007 are presented. Since December 2005 eight more aliens have been found in the area increasing the total number to 110. these species are:

1. MOLLUSCA; GASTROPODA; OPISTHOBRANCHIA: CHROMODORIS ANNULATA (ELIOT, 1904)

Chromodoris annulata is a tropical species commonly found in both the western and northern Indian Ocean. A single

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Table 1. Total number (N) of alien fish, zoobenthos and zooplankton species recorded in Greek waters in December 2005 (as from Pancucci-Papadopolou, 2006) and in July 2007 (this paper).

	December 2005 N	July 2007 N	Change
Fish	32	33	+1
Zoobenthos	63	68	+5
Zooplankton	7	9	+2
Total	102	110	

specimen was found alive in a rock pool in August 2004 in Salamina, Saronikos Gulf (Figure 1). The appearance of *C. annulata* could be one more case of introduction via the Suez Canal. However, the absence of records from the Levantine Sea, combined with the finding of a particular colour form, that lies exclusively in the Arabian Sea, near a port area (Piraeus), leads to the assumption that the species has been transported via shipping (Daskos & Zenetos, 2007).

2. CRUSTACEA; AMPHIPODA: CAPRELLA SCAURA TEMPLETON, 1836

Caprella scaura Templeton, 1836, was first recorded from Mauritius and later reported from many places all over the world, while in the Mediterranean it was first described in collections made during the period 1994–1995 in the Lagoon of Venice (Krapp *et al.*, 2006). In Greek waters it was collected in the Amvrakikos Gulf, a semi-enclosed gulf forming one of the major embayments of the Ionian Sea. At the entrance of the gulf there is the large yacht harbour of Preveza, and *C. scaura* could have arrived there carried via shipping. On the other hand, for the last couple of decades a few aquaculture enterprises using fish cages have been operating in the gulf, representing a possible vector of the species introduction in the area (accidentally with aquaculture transfers).

3. CRUSTACEA; DECAPODA: CHARYBDIS HELLERI (MILNE-EDWARDS, 1867)

This is a species of Indo-Pacific origin, distributed throughout the Indian Ocean, including the Red Sea. Presumably introduced in the eastern Mediterranean via the Suez Canal, it has been reported in Israel, Egypt, Turkey, Lebanon, Syria and Cyprus (Galil *et al.*, 2002). The first finding in Greece took place in the Dodecanese Isles complex (Rhodes, Symi)



Fig. 1. *Chromodoris annulata* from Salamina.
Photograph: A. Daskos.

in 2004 (Kirmirtzoglou *et al.*, 2006) documenting its further immigration into the eastern Mediterranean.

4. POLYCHAETA; NEREIDIDAE: PSEUDONEREIS

ANOMALA (GRAVIER, 1900)

Pseudonereis anomala (Polychaeta) (Figure 2) is a Red Sea immigrant reported in Greek waters at a time when the species was also recorded along the Aegean Turkish coast (İzmir Bay: Çinar & Ergen, 2005). A total of 55 specimens were collected in the harbour of Piraeus (Saronikos Gulf) and 5 specimens in the harbour of Kalamata (South Aegean). Its presence in large numbers in the Suez Canal (Ben-Eliahu, 1991) suggest its introduction by lessepsian migration in the Mediterranean. However, its presence inside and near the harbours suggest secondary introductions by shipping activity (Kambouroglou & Nicolaidou, 2006).

5. POLYCHAETA, SABELLIDAE: BRANCHIOMMA

LUCTUOSUM (GRUBE, 1869)

Branchiomma luctuosum, a sabellid of Red Sea origin, is known to have entered the Mediterranean via fouling since 1983 when it was first reported from Italy (Giangrande, 1989). Nowadays it has been recorded as far south as the Cypriot and Turkish coasts of the Levantine Sea (Çinar, 2005; Çinar *et al.*, 2006) and as far west as Valencia port, Spain (El Haddad *et al.*, 2007).

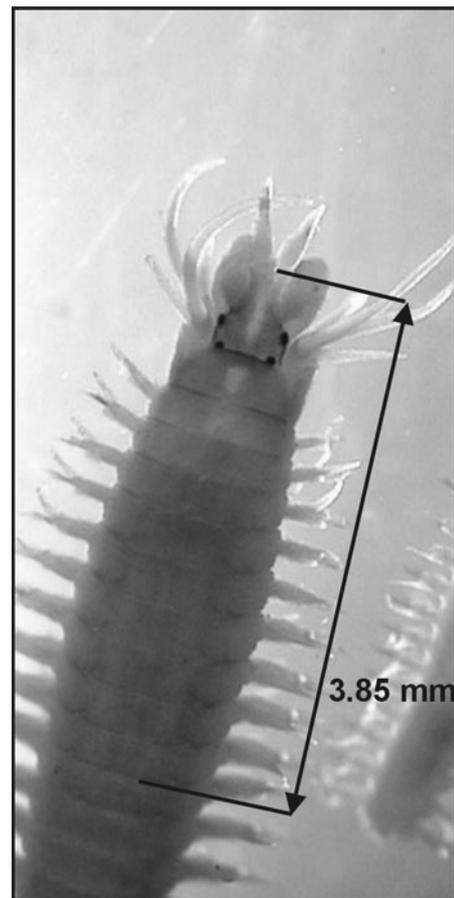


Fig. 2. *Pseudonereis anomala* from Peiraias port.
Photograph: V. Kambouroglou.



Fig. 3. *Branchiomma luctuosum* from Salamina.
Photograph: J. Issaris.

In Greece, although not reported by Pancucci-Papadopoulou *et al.* (2005), it was first collected in Strymonikos Gulf, northern Aegean Sea (Arvanitidis, 2000). Quite recently, the species (Figure 3) was found in Saronikos Gulf, Salamina Island. A well established population of *B. luctuosum* was sighted in two small bays which are affected by shipping and sewage. This finding is in accordance with all previous publications suggesting that the species is favoured by anthropogenic impact, mainly colonizing harbours or sewage disposal sites (Matarrese *et al.*, 2004; Mastrototaro & Dappiano, 2005; Çinar & Ergen, 2005; Çinar *et al.*, 2006).

6. CNIDARIA; SCYPHOZOA; MEDUSAE: *RHOPILEMA NOMADICA* GALIL, 1990

The scyphomedusa *R. nomadica* is a lessepsian immigrant established in the Levantine Sea. In Greece it was recorded in outer Lakonikos Gulf (south Peloponnese) in July 2006 (Figure 4) (Siokou-Frangou *et al.*, 2006). The jellyfish's painful stings may pose a danger to swimmers and serious problems to local fishermen. Because of its invasiveness



Fig. 4. *Rhopilema nomadica* from Skoutari Bay, Lakonikos Gulf. Photograph: K. Sarantakos.



Fig. 5. *Beroe ovata* from Evvoikos Gulf, north Aegean. Photograph: E.D. Christou.

and its impact it is considered among the worst invasive marine species in European seas. Anonymous contributors reported also that during 2006 the species was encountered frequently in coastal waters of Elia, inner Lakonikos Gulf.

7. CNIDARIA; CTENOPHORA; *BEROE OVATA* MAYER, 1912

Beroe ovata is a west Atlantic, Indo-Pacific species with much confusion surrounding its nomenclature and attribution of authorship (Mills *et al.*, 1996). Introduced into the Black Sea in 1997 (Konsulov & Kamburska, 1998), the species spread around the whole Black Sea and created its own reproductive population in 1999 (Finenko *et al.*, 2000). In 1999, individuals of this species were found in the Sea of Marmara near the Bosphorus area for the first time (Tarkan *et al.*,



Fig. 6. *Torquigener flavimaculosus* from Rhodes.
Photograph: M. Corsini-Foka.

2000). Previous records of the species in the Mediterranean are considered as mis-identifications of its congeneric *Beroe* cf. *cucumis* (Shiganova *et al.*, in press). Its finding in the north Evvoikos Gulf is presumably due to transfer from the Black or Marmara Seas via currents (Shiganova *et al.*, in press).

8. CHORDATA, ACTINOPTERYGII; TELEOSTEI:

TORQUIGENER FLAVIMACULOSUS HARDY & RANDALL, 1983

The pufferfish *Torquigener flavimaculosus* Hardy & Randall, 1983 is a lessepsian immigrant to the eastern Mediterranean via the Suez Canal (Golani *et al.*, 2006). Three specimens (Figure 6) were collected by trawlers at Yalissos, Trianda Bay, on the north-western coasts of Rhodes, at depths between 30 and 50 m, over a sandy–muddy bottom covered with *Posidonia* beds (Corsini *et al.*, 2006).

B. Expansion of distribution of known species

1. MOLLUSCA: OPISTHOBRANCHIA: APLYSIA

DACTYLOMELA RANG, 1828

The species was recorded for the first time in Greek waters on 19 June 2005, in Rhodes Isle, Aegean Sea (Sterniuk-Gronek, 2005), and then in the same period (13–17 July 2005) it was also found in Stoupa, south Peloponnese (David, 2005). In 2006, four more sightings off Rhodes (Figure 6) (Salomidi, 2006), Crete (Andersson, 2006), Paros and Saronikos (A. Zenetos, personal observation), document that the species is well established in Greek waters.

2. MOLLUSCA: OPISTHOBRANCHIA: HAMINOEA

CYANOMARGINATA HELLER & THOMPSON, 1983

Haminoea cyanomarginata is a Red Sea species, first recorded in the Mediterranean in the Korinthiakos Gulf, Greece (Zenetos *et al.*, 2004). The species has become abundant on the south-western coasts of Turkey, where in some regions tens of them can be observed during a dive (Yokes, 2005). Its finding in Saronikos Gulf, attached to *Posidonia* at a depth of 25 m on 8 October 2005 (Mifsud, 2005), provides further evidence of its establishment and dispersal in Greek waters.

3. MOLLUSCA: OPISTHOBRANCHIA: BURSATELLA

LEACHII (DE BLAINVILLE, 1817)

Bursatella leachii is a circumtropical species widespread along the temperate water of the Indo-Pacific and Atlantic Oceans. The species has been recorded for the first time in eastern Greece in Chios and Lesvos Isles (Barash & Danin, 1986) and then in northern Greece, in the Thermaikos Gulf and the Chalkidiki peninsula (Koutsoubas, 1992), but its first sighting in the Aegean took place on Turkish coasts (Swennen, 1961). In addition to its recent finding in Greek waters of the south and central Aegean (Crete Island and Korinthiakos Gulf: Daskos & Zenetos, 2007), the species was sighted in Doroussa Island, Saronikos Gulf (M. Salomidi, personal observation).

4. MOLLUSCA, GASTROPODA: STROMBUS PERSICUS

SWAINSON, 1821 (ROEDING, 1798)

Strombus persicus is a subtropical species restricted to the south Arabian and part of the Iranian coast, that has

entered the Mediterranean presumably via the Suez Canal and has become locally invasive in the south-eastern Mediterranean including several Greek localities such as Rhodes, the south Peloponnese coasts and Argolikos Gulf (Zenetos *et al.*, 2004). Herein, its northward expansion is reported in the Saronikos Gulf (central Aegean), where it was first observed on the beach of Kalivia (Attiki coast near Athens) in October 2004 (Young, 2007). Additional sightings of the species include several other sites along the Attiki coast of the Saronikos Gulf from Cape Sounion to Agia Marina (L. Young, personal communication).

5. MOLLUSCA, BIVALVIA: FULVIA FRAGILIS

(FORSKÅL IN NIEBUHR, 1775)

A well established mollusc, widely distributed in the Levantine basin (Zenetos *et al.*, 2004) and recently recorded in the western Mediterranean (Spain: Zenetos *et al.*, 2004; Italy: Crocetta, 2005). The species was common in Elefsis Bay, Saronikos Gulf (Vardala-theodorou, 1999) where it exhibited an invasive character. Recently it has expanded in the wider Saronikos Gulf. The present study reports on its occurrence off Chalkoutsis in Evvoikos Gulf (collection of A. Zenetos).

6. MOLLUSCA, BIVALVIA: PINCTADA RADIATA

(LEACH, 1814)

An Indo-Pacific species, well established in the eastern Mediterranean (Zenetos *et al.*, 2004). Besides its adaptation to the subtropical environment of the south-eastern Mediterranean, its tolerance to chemical contamination has enhanced its expansion in enclosed polluted ecosystems.

Most of the places it has been reported on Greek coasts coincide with areas where it was originally introduced for aquaculture. However, the present records in the Kyklades Isles complex in 2006 (Serifos: Agios Giannis, collection of A. Zenetos) and in Crete in 2003 (Ormos Paliokastro, collection of D. Poursanidis) support the species parallel introduction in Greek waters via the Suez Canal.

7. CHORDATA, OSTEICHTHYES, TELEOSTEI:

LAGOCEPHALUS SUEZENSIS (CLARK & GOHAR, 1953)

This Indo-Pacific fish species was first recorded in the Mediterranean from Lebanese coasts by Mounime (1977), who according to Golani (1996) mis-identified it as *Lagocephalus sceleratus* (Gmelin, 1789). It is now well established in Israel, Lebanon, Syria and south Turkey (Golani *et al.*, 2006). In Greece, it was first recorded from the Ialissos-Trianda Bay of the island of Rhodes, where it was caught in 2003 (Corsini *et al.*, 2006). This work reports an additional collection, by recreational fishermen, of seven specimens with total length ranging between 120 and 154 mm in Symi Island, south Aegean on 25 September 2006.

8. CHORDATA, OSTEICHTHYES, TELEOSTEI:

LAGOCEPHALUS SCELERATUS (GMELIN, 1789)

The first confirmed sighting of the species in Mediterranean waters came from the south-eastern Aegean coast of Turkey in 2003 (Akyol *et al.*, 2005). In Greece, it was recorded for the first time off Rhodes Isle in September 2005 (Corsini *et al.*, 2006) and during the same year it was also recorded in northern Crete (Kasapidis *et al.*, 2007a). Since then, several samples (identified by scientists of the HCMR) and reports regarding its occurrence in different places in the

central and northern Aegean, Cretan and Libyan Seas have been provided by fishermen, indicating the rapid expansion of the species (Peristeraki *et al.*, 2006).

9. CHORDATA, OSTEICHTHYES, TELEOSTEI:

SPHOEROIDES PACHYGASTER (MÜLLER & TROSCHEL, 1848)

The species is found in a wide depth range, from 40 m down to 480 m of depth and its geographical distribution ranges from tropical to temperate seas throughout the world (Froese & Pauly, 2005). In the Mediterranean Sea, *S. pachygaster* was reported for the first time in 1979 from the Balearic Islands (Oliver, 1981), and subsequent findings of the species took place in various areas of the western and central part of the Mediterranean region. In the eastern Mediterranean, no record of the species existed before 1991, when a specimen was collected by a trawl in Israel (Golani, 1996). In Greek waters five specimens of the species were collected off Rhodes Isle in 1992 (Zachariou-Mamalinga & Corsini, 1994). This work reports on the collection of two specimens with total length of 297 mm and 436 mm in depths of about 150 m off Serifos Isle (central Aegean) in October 2005 in the frame of the Greek Data Collection Regulation Programme. Moreover, according to the data existing in the HCMR database, additional collection of *S. pachygaster* specimens took place in 2000 off Serifos, and at the south of Meganissi Isle in the Ionian Sea, as well as in 2004 and 2005 at the north of Lefkas Island (Ionian Sea); the 16 specimens that were collected in the Ionian Sea had total lengths ranging from 297 to 398 mm, while the single specimen that was caught off Serifos had a total length of 164 mm. The above data suggest the presence of recently established populations of the species in the aforementioned areas of Greek waters.

10. CHORDATA, OSTEICHTHYES, TELEOSTEI:

ETRUMEUS TERES (DEKAY, 1848)

Etrumeus teres is a commercially important small pelagic fish species distributed off southern African coasts, in the western Indian Ocean, the Red Sea and the Sea of Japan, as well as in Australian waters and in the western Atlantic and the eastern Pacific. Ben-Tuvia (1966) reported the first appearance of the species in eastern Mediterranean waters. In Greek waters it appeared for the first time off Rhodes Isle in 2003 (Corsini *et al.*, 2005). Then, in 2004 it was collected in the area of the Kyklades (Kallianiotis & Lekkas, 2005) and in 2005 off northern Crete (Kasapidis *et al.*, 2007b). This work reports the collection of a single specimen of *E. teres*, having a total length of 212 mm, in the frame of the Greek Data Collection Regulation Programme, on-board a commercial purse seiner off north-eastern Hydra Island (central Aegean) on 11 November 2005. The specimen is deposited in the fish collection of the HCMR (Athens).

11. CHORDATA, OSTEICHTHYES, TELEOSTEI:

UPENEUS MOLUCCENSIS (BLEEKER, 1855)

An Indo-Pacific species that has been recorded in eastern Mediterranean waters since the 1930s, and in some areas (off Israel and the south Turkish coast) it has become commercially important to trawl fishery (Golani *et al.*, 2006; Galil, 2007). In Greek waters it was reported for the first time off Rhodes Isle in 1947, when it displayed a significant population

explosion (Laskaridis, 1948a), followed however by a dramatic decline and considered ever since as a rare species in the area (Corsini & Economidis, 1999). In September 1995 and May 1996 the species was collected during experimental trawl survey samplings conducted by HCMR in waters off the Dodecanese (a total of 4 specimens with total lengths ranging from 106 to 117 mm: respectively two off north Kalymnos Isle and another two off north Kos Isle). In May 1996 a specimen was also collected at a site south of Sikinos Isle (Kyklades plateau). Peristeraki *et al.* (2006) reported its finding in Crete, south Aegean on 19 June 2006 in the context of the Greek Data Collection Regulation Programme (MEDITS experimental trawl survey).

12. CHORDATA, OSTEICHTHYES, TELEOSTEI:

SARGOCENTRON RUBRUM (FORSSKÅL, 1755)

A species presenting a distributional range from the Red Sea to the western Pacific, where it appears from southern Japan to New Caledonia and New South Wales, Australia. According to Randall *et al.* (1990) it is a venomous fish. It was first recorded in eastern Mediterranean waters in 1947 from Israel (Golani, 1998a) and almost at the same time from north-east Rhodes as *Holocentrum rubrum* (Laskaridis, 1948b). A later finding of the species (Papaconstantinou *et al.*, 1988) is from the Dodecanese Islands complex (Kastellorizo, Symi), where the species was rare. This work reports the finding of one specimen off Leros Island (July, 2007).

DISCUSSION

The present study reports the presence of eight new alien species in Greek waters, increasing the total number of alien fauna to 110. These species seem to have different methods of introduction: *Charybdis helleri*, *Rhopilema nomadica* and *Torquigener flavimaculosus* are well-known lessepsian immigrants, which might have reached Greek waters through the progressive expansion of their distribution westwards. *Chromodoris annulata*, being absent in Levantine waters, could have been transported via shipping. *Beroe ovata*, recently introduced in the Black Sea and also present in the Marmara Sea, is assumed to have penetrated with currents via the Dardanelles Straits. The establishment of *Caprella scaura* might also result from shipping activities, and in fact according to Krapp *et al.* (2006) this species might have travelled in Mediterranean waters living among fouling on the hulls of the ships. *Pseudonereis anomala* and *Branchiommata luctuosum* seem to have a two-fold origin, part arising from shipping activities, and part through its progressive migration from the Suez Canal westwards in the Mediterranean. The above are in accordance with the European Environment Agency (EEA, 2006) stating that the Suez Canal has been the largest pathway for the entry of invaders into the Mediterranean Sea, the next major vectors of introductions being shipping and then aquaculture.

New evidence on the expansion range of 12 aliens, with already established populations in some areas of Greece, is also presented. Previous records revealed the existence of the alien species in south-eastern Greek waters and the present findings showed their further expansion westwards, where they appeared mainly in areas of the south-central

Aegean Sea. Zenetos *et al.* (2005a) reported that among the Greek Seas, the Aegean and in particular the south Aegean is the area where the majority of the alien mollusc species is distributed mainly due to its vicinity within the Levantine Basin and to the influx of the Levantine intermediate water there (Kontoyiannis *et al.*, 2005) supplying these waters with elements of Indo-Pacific origin. Only the teleost *Sphoeroides pachygaster* appeared also in different areas of the Ionian Sea, which could be in accordance with the fact that the species is considered a recent immigrant of Atlantic origin, but the possibility mentioned by Psomadakis *et al.* (2006), that it could be also introduced into eastern Mediterranean waters via the Suez Canal, cannot be excluded. In any case, beside the significance of the south-eastern Aegean Sea as the main pathway of lessepsian immigrants spreading within the Mediterranean, particular notice should be also paid to the species found in Saronikos Gulf, an area closely related to the route of ships towards the biggest Greek port of Peiraias, and one of the most heavily polluted marine regions in Greece (Hatzianestis & Botsou, 2005). Galil (2000) mentioned that polluted or physically degraded environments are more prone to invasion of alien species than are pristine sites. The fact that vessel-transported aliens are mostly restricted to polluted harbours (Zibrowius, 1992), environments that are known for their low biodiversity, support this theory.

Golani (1998b) underlined that once a lessepsian species has established a self-sustaining population in the Mediterranean Sea, there are no physical barriers precluding its dispersal westward. The latter is of particular importance when the species becomes invasive, which seems to be the case for the jellyfish *R. nomadica*, whose large aggregations along certain eastern Mediterranean coasts have negative consequences on human health, tourism and fisheries activities (Kideys & Gucu, 1995). Moreover, the poisonous puffer-fish *Lagocephalus sceleratus*, recorded for the first time in the Mediterranean in 2003 (Akyol *et al.*, 2005), can be considered as one of the faster expanding lessepsian immigrants, and is at present encountered very frequently in fish catches off Crete. Its establishment in the latter area and the possible negative impacts to the ecosystem, fisheries, and human health in case of accidental consumption, have received significant attention by the scientific community and the media. It should be stressed that the latter two species have been included among the 100 'worst invasive species' in the Mediterranean (Zenetos *et al.*, 2005b; Streftaris & Zenetos, 2006). Another lessepsian immigrant, however, the teleost *Fistularia commersonii* (Rüppell, 1838), which was reported by recreational fishermen to exist in the Saronikos Gulf, seems also to present a rapid expansion in the Mediterranean (Karachle *et al.*, 2004; Pais *et al.*, 2007) but it was not included in the present paper since these reports were not verified. In fact Corsini *et al.* (2002) off Rhodes Isle has found that the latter species preyed upon several exploited native populations of economic importance suggesting that the permanent establishment of a large population in the area might be harmful to the resources, with consequent impacts on local fisheries.

Invasions by alien species are now widely recognized as a major cause of biodiversity loss and as a setback to development. Effective management strategies aimed at reducing new invasions and their impacts are immediately needed and they definitely require a concerted effort of multiple

disciplines, the first step being a comprehensive reporting system highlighting new invasions and monitoring the spread of alien species into new areas.

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